高密度高分辨标测下外科术后房性心动过速的电生理特征

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摘 要：【目的】观察在高密度、高分辨率视觉下的心外科术后房性心动过速（房速）的电生理特点及消融效果。【方法】回顾分析自2016年3月至2019年12月在中山大学附属第一医院因心外科术后房速，应用Orion微电极网蓝与Rhythmia标测系统进行标测消融治疗的全部患者。【结果】共入选21名患者，总共记录到26种房速，平均每种房速的标测时间为（19.1±7.1）min，所采取的电图（19 495±12 798）个。26种房速中，按部位分：20（76.9%）个位于右房，5（19.2%）个位于左房，1（3.8%）个为左右双房大折返；按心动过速机制分：24（92.3%）个为大折返房速，1（3.8%）个为微折返，1（3.8%）个为局灶房速。在大折返房速中，7个为双环“8”字折返，消融一环过程中有4个转为单环折返。另有一例为跨房间隔传导的双房大折返。21例患者2例复发，其中1例当时仅对游离壁疤痕至下腔静脉的连线进行消融，后再次手术时标测为三尖瓣峡部依赖性房速。【结论】心外科术后房速形式多样，以大折返房速为主，极少数为微折返或局灶起源。大折返房速可表现为双环折返或双房大折返。消融时除针对本次心动过速外，还需根据心房的基质情况进行预防性干预。

关键词：心外科术后房性心动过速；高密度标测；微电极；消融
中图分类号：R541 **文献标志码：**A **文章编号：**1672-3554(2021)01-0095-07

Electrophysiologic Characteristics of Post-cardiac-surgical Atrial Tachycardia under Ultra-high Density and High-resolution Mapping

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Abstract:【Objective】To explore the electrophysiologic characteristics of post-cardiac-surgical atrial tachycardia (AT) under ultra-high density and high-resolution mapping.【Methods】Consecutive cases with post-cardiac-surgical AT and taking mapping using Orion basketball mini-electrode and Rhythmia mapping system were collected and analyzed in the first affiliated hospital of Sun Yat-sen University from march 2016 to december 2019.【Results】Totally 26 ATs were recorded in the 21 patients with a mean mapping time (19.1±7.1)min. Among them, 20 (76.9%) ATs located in right atrium, 5 (19.2%) in left atrium, and one was a bi-atrial macro-reentrant AT. According the difference of tachycardia mechanism, 24 (92.3%) were macro-reentrant ATs, one was micro-reentrant, and the other was local activation. In the macro-reentrant ATs, 7 cases showed a dual-loop reentrant circuit configurated “figure-of-eight”, one was a bi-atrial macro-reentry with a transmural conduction from left side to right side of atrial septum. During ablation, 4 patients in the 7 cases with “figure-of-eight” dual-loop reentries turned into a single-loop reentry. During follow-up with an average of 16 (4, 36) months, 2 cases recurred, and one was because of no prophylactic ablation on the tricuspid isthmus.

收稿日期：2020-08-12
基金项目：广东省科技计划项目（2015B010106007）
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【Conclusions】Post-cardiac-surgical atrial tachycardia mainly manifests as complicated macro-reentrant AT. Some show a dual-loop reentry and sometimes a bi-atrial macro-reentry. During ablation, some prophylactic ablation according to the substrate is necessary.

Key words: post-cardiac-surgical atrial tachycardia; ultrahigh-density mapping; mini-electrodes; ablation

[J SUN Yat-sen Univ(Med Sci),2021,42(1):95-101]

心外科手术后常发生房性心动过速(房速),文献报道发病率为10%~80%不等[1-2]。虽然消融治疗是目前针对此类心律失常的主要方式,但由于潜在的心源性疾患及外科切口所致的医源性心房基质变化,使得房速发生机制复杂,常规标测治疗的难度较大,复发率较高[3-4]。高密度、高分辨的标测有利于复杂心律失常的标测诊断[5-7],Orion微电极网蓝由64个平面微电极(0.4 mm^2)构成,与Rhythmia标测系统(Boston Scientific, Marlborough, MA, USA)联合,能自动快速获得超高密度、高分辨率的三维电解剖图。因而本研究应用此系统,观察在超高密度高分辨率视角下心脏外科术后房速的电生理及消融治疗特点。

1 材料与方法

1.1 实验对象

选自2016年3月至2019年12月在中山大学附属第一医院因心外科术后房速,应用Orion微电极网蓝与Rhythmia标测系统进行标测消融治疗的全部21例患者。其中法洛四联症2例,风湿性心瓣膜病8例,先天性二叶主动脉瓣畸形1例,老年性心瓣膜病1例,房、室间隔缺损8例,右室双腔心1例。本研究所有检查均得到纳入患者知情同意,并通过中山大学附属第一医院伦理委员会批准。

1.2 电生理标测

术前停用抗心律失常药至少5个半周期(胺碘酮至少停用2周)。手术时,局麻后经右侧颈内静脉或左股静脉置入十极电极到冠状窦作为心电及解剖参考。应用Orion微电极网蓝三维标测右房或左房,明确心动过速的类型或位置。标测时将消融电极放置在下腔静脉作为单极参考,心房激动根据下列条件自动获取:①周期的稳定性(±5 ms);②冠状窦参考电极的相对时间;③呼吸门控;④标测导管的稳定性。网蓝电极的信号滤波设置:双极高通30 Hz,低通500 Hz;单极高通0.5 Hz,低通500 Hz。电压置信阈值(confidence mask)设置在0.03 mV。心肌局部激动时间根据系统的标注软件(Intelligent Annotation)自动确定。简单地说,系统对单组分的双极电位,将局部激动时间定义在最大的峰电位上,单极电图将局部激动时间定义在最大的负向dV/dt上;对碎裂或复杂多峰电位,局部电位的标注同时参考单极电位及周围其他点的局部激动时间[7-8]。根据标测结果,如果心动过速的全周长均被标出,且激动首尾相接,则为折返;其中当折返环局限在直径不到2 cm范围之内时,则为局灶折返,反之为大折返[9];局灶起源则表现为激动由腔壁的某一点发出,向周围扩布,整个心腔的激动时间一般小于心动过速周长。

1.3 消融与随访

消融采用盐水灌注大头(Therapy Cool Path Duo™, St. Jude Medical, Inc, USA)功控模型下进行(30~35 W, 43 ℃, 17 mL/min),如为局灶性房速,则针对起源点进行消融;如为折返性房速,则先针对解剖或电生理峡部进行消融,转律后再尽量将可能的解剖峡部进行消融阻断,预防其他类型的心动过速发作,例如在右房游离壁有疤痕的三尖瓣峡部依赖的房扑中,在三尖瓣峡部消融后,一般在游离壁沿疤痕向下腔消融一阻滞线。消融终点为心动过速终止、消融线达到双向阻滞,并在应用异丙肾上腺素前后心房程序刺激均不能诱发心动过速。所有患者术后不应用抗心律失常药,无症状时常规3、6、12月行心电图或24 h动态心电图监测,有症状时随时进行心电图检查。

2 结 果

2.1 临床资料

在选取的21例患者中,男性14例,女性7例,年龄(46±14)岁。从心外科手术到症状出现中

位时间为84(10~468)月,其他如心外科的手术类型,心律失常病程,入院时NYHA心功能分级,左室射血分数、左右房内径、左室舒张末期内径等见表1。

2.2　电生理标测结果

2.2.1　一般结果　心内电生理检查过程中,21名患者共记录到26种房速,其中有5名患者在消融过程中或消融后电刺激时转为/诱发出另一种房速。每种房速均用Orion网蓝电极与Rhythmia系统进行了标测,平均标测时间为(19.1±7.1) min,标测的心搏数为(2 662±1 260)次,所采取的电图(19 495±12 798)个;心动过速的周长平均为(258±49) ms。

2.2.2　房速的类型　26个房速中,20(76.9%)个位于右房,5(19.2%)个位于左房,1(3.8%)个为双房大折返。如按心动过速机制分:24(92.3%)个为大折返型房速,1(3.8%)个为界嵴局灶房速(周长为400 ms,为逆钟向三尖瓣峡部依赖性房扑消融后诱发),1(3.8%)例为左房前壁局灶折返(图1)。在大

表1　病人一般资料

Table 1　Baseline patients characteristics　　(n=21)

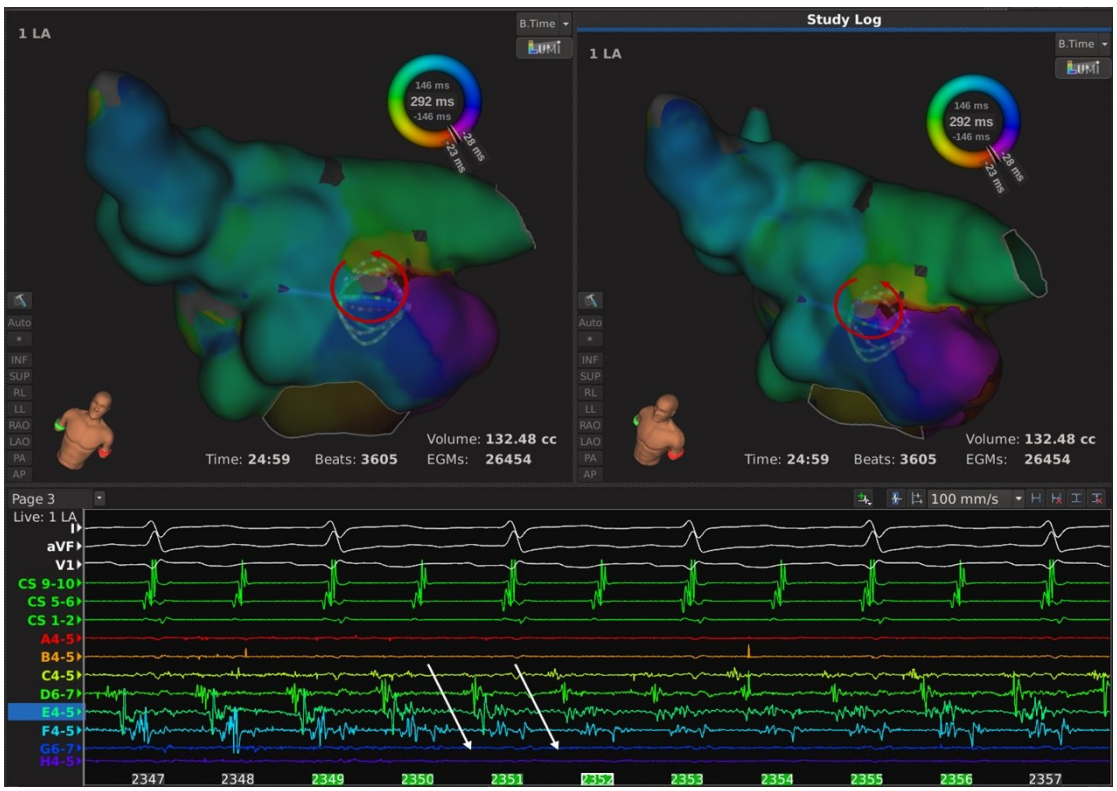
Characteristics	Overall
Male sex	14/21
Age/years	46±14
Type of cardiac surgical operation	
MVR	4
MVR+AVR	4
AVR	1
MVR+TVR	1
RVSD	3
RASD	2
RASD+RVSD	1
RASD+MVP+TVP	1
RASD+TVP+Maze	1
Repair of tetralogy of Fallot	2
Repair of DCRV	1
Time interval between operation to atrial tachycardia(m)	84(10~468)
UCG	
LA/mm	48.3±9.8
RA (Length×width)/mm×mm	(40.2±10.0)×(38.6±8.0)
LVEDD/mm	47.9±6.3
EF/%	62.9±10.1
NYHA class	
Ⅰ	5
Ⅱ	15
Ⅲ	1
Ⅳ	0

MVR: mitral valve replacement; AVR: aortic valve replacement; TVR: tricuspid valve replacement; RASD: repair of auricular septal defect; RVSD: repair of ventricular septal defect; MVP: mitral valvuloplasty; TVP: tricuspid valvuloplasty; Maze: maze operation; DCRV: double-chambered right ventricle; LA: left atrium; RA: right atrium; LVEDD: left ventricular end-diastolic diameter; EF: ejection fraction.

折返房速中,单纯三尖瓣峡部依赖的房扑8例(其中6例为逆时钟);三尖瓣峡部依赖的房扑并绕游离壁疤痕呈"8"字双环折返4例(其中3例三尖瓣峡部依赖的房扑为逆钟向),共同峡部位于游离壁疤痕与三尖瓣之间(图2A);环下腔折返2例;单纯绕右房游离壁疤痕3例(均由上述"8"字折返消融三尖瓣峡部后转变而成);经右房游离壁上下两疤痕中间(共同峡部)突破的"8"字双环折返1例(图2B);二尖瓣峡部依赖的房速2例(逆钟向、顺钟向各1例);逆钟向二尖瓣峡部依赖及绕房间隔疤痕"8"字折返1例,共同峡部位于房间隔疤痕与二尖瓣环之间,消融二尖瓣峡部后变成绕间隔疤痕的折返;绕左房后壁疤痕及右肺静脉"8"字折返1例,共同峡部位于后壁疤痕与右肺静脉之间;依赖左房间隔面逆钟向三尖瓣峡部依赖的双房大折返1例,此时在右房间隔面可见一跨膜传导的突破(图3),另外这种跨膜突破也见于两例游离壁疤痕相关的房速中。

2.2.3 "8"字双环折返的消融过程 在24例大折环房速中,有7例表现为"8"字双环折返。其中4例三尖瓣环,1例二尖瓣环是其折返环之一,3例在消融三尖瓣峡部及1例在消融二尖瓣峡时,心动过速的周长发生了延长,心房激动顺序发生了改变,均变成了沿另一折返环激动的单环折返;2例在消融共同峡部时心动过速终止(1例为右房游离壁两疤痕之间(图2B),另1例为左房后壁疤痕与右肺静脉之间)。1例绕三尖瓣及游离壁疤痕的病例在消融三尖瓣峡部时终止。

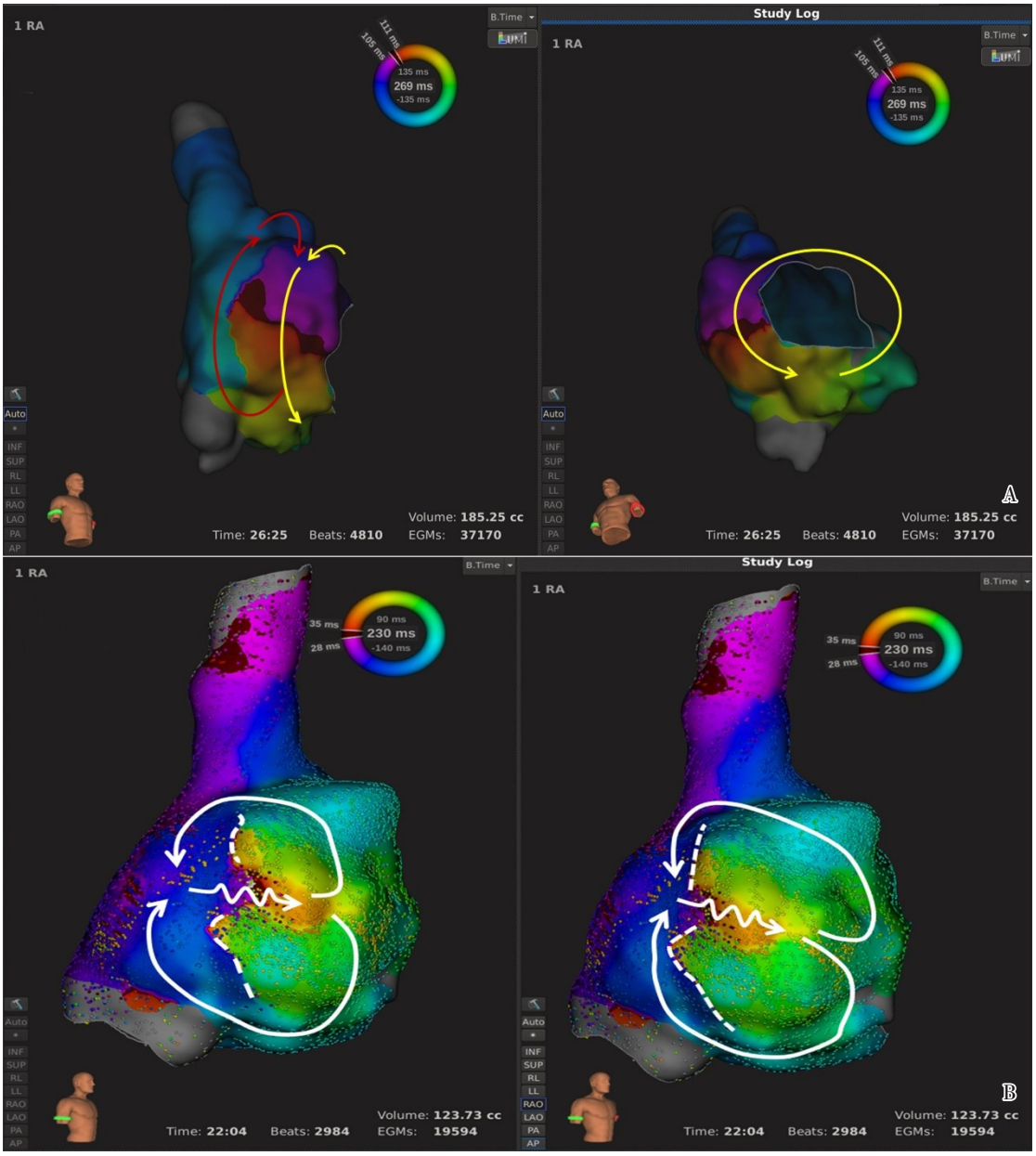
2.2.4 消融结果与随访 所有患者均消融终止心动过速,术中未见有任何并发症。中位随访16(4,36)个月,有2例患者复发。其中1例为经右房游离壁上下两疤痕中间突破的"8"字折返患者(图2B),当时只消融了共同峡部,将上下两疤痕连接起来,并向下延伸至下腔,此次发作为逆钟向的三尖瓣峡部依赖的房扑,消融阻断三尖瓣峡部后随诊1年未再复发。另一例为顺钟向型三尖瓣峡部依赖的房速患者,阵发发作,拒绝再次手术。



A focal reentrant atrial tachycardia existed around a small scar located in the front wall of left atrium (red circular arrow). Long fractionated potentials could be recorded in the region (white arrows).

图1局灶折返房速

Fig. 1 Focal reentrant atrial tachycardia



A: A longitudinal scar existed in the free wall of right atrium. A dual-loop reentrant atrial tachycardia showed a figure-of-eight configuration. One loop was a counter-clockwise cavo-tricuspidisthmus dependent circuit (yellow circular arrow), and the other loop rotated clockwise around the scar (red arrow). B: Common isthmus existed between the two scars in the free wall of right atrium.

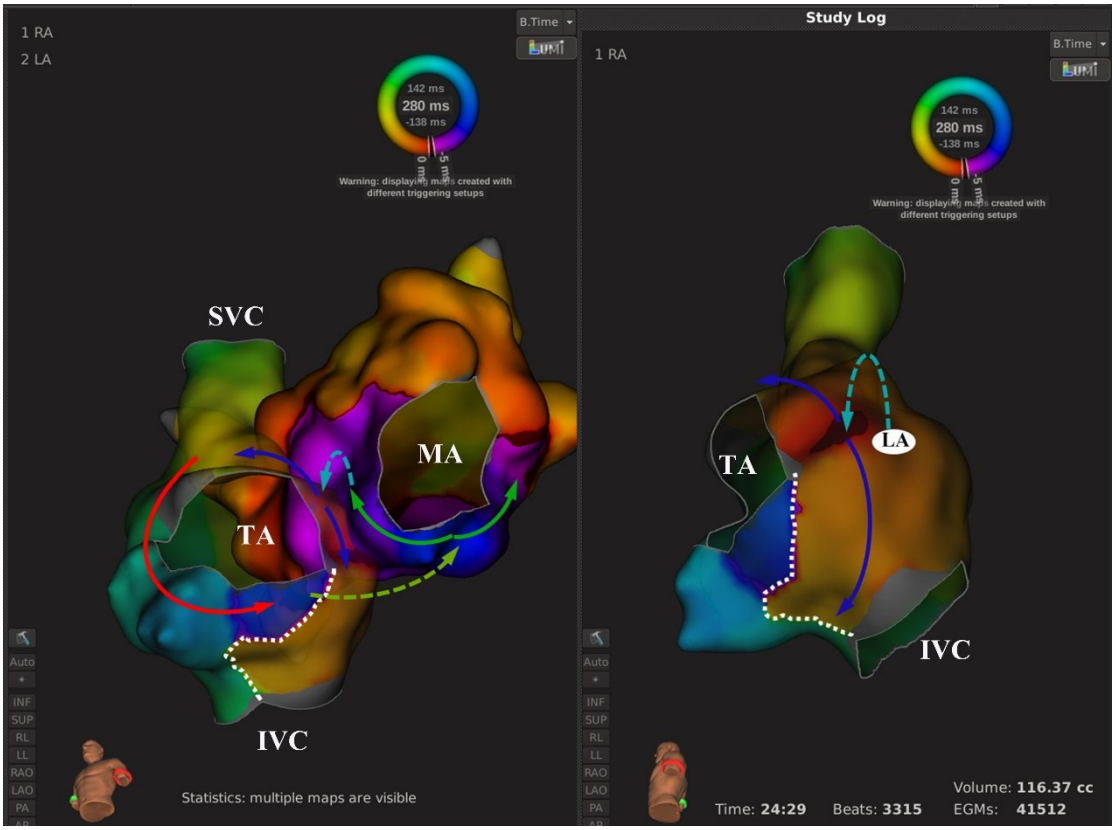
图2双环"8"字折返

Fig. 2　Dual-loop reentrant circuits configurating "figure-of-eight"

3　讨　论

由于基础心源性疾病与手术切口损伤对心房基质的共同影响,心外科手术后的房性心动过速常表现复杂。常规标测方法在明确心动过速的类型或折返径路上常常面临巨大挑战,有时需花费较长时间和联合应用起搏拖带等手段才可"推断"完成。大量的研究表明小极间距微电极能明显提高标测准确性与分辨率,有利于发现电位的细微情况和基质细节,结合超高密度标测有利于复杂心律失常的诊断[5-6, 8]。本研究发现应用超高密度、高分辨率的标测系统能快速标测出心动过速类型与机制(平均19.1 min),根据标测的结果进行相应的消融治疗均能终止心动过速。

心外科术后的房速可表现为折返(包括大折返与微折返)或局灶激动。既往有研究提示大折返是



Endocardial block existed along the paraseptal-central isthmus obliquely from the tricuspid annulus to inferior vena cava. Activation mapping showed that the reentry circuit was a bi-atrial macro-reentry. Counterclockwise activation propagated to the lateral side of the endocardial block line at the isthmus (red arrow line) and then conducted to the LA (yellow-green broken arrow line), and further propagated upwards along the left atrial septum (green arrow line) and jumped into the RA through transmural breakthrough (light blue broken arrow line), and continued to activate the RA free wall (blue arrow line). TA: tricuspid annulus; MA: mitral annulus; LA: left atrium; IVC: inferior vena cava; SVC: superior vena cava

图3双房大折返

Fig. 3 Bi-atrial macro-reentrant atrial tachycardia

其主要类型，约占92.1%，而微折返或局灶分别为1.6%、6.3%[10]。本研究26个房速中有24个(92.3%)为大折返型房速[11]，而微折返和局灶房速各只有1例，进一步说明了大折返房速是心外科术后的主要房性心动过速类型。同时，由于心房存在各种外科手术疤痕或基质改变，可产生多个不同的结构或功能的电传导阻滞，大折返房速的折返环常比较复杂，可表现为双环或多环折返。在本组19例初始心动过速标测为大折返房速的患者中，7例为“8”字双环折返，其中4例在消融其中一个折返环过程中，心动过速周长发生延长[12]，心动过速演变成了单纯沿另一折返环的单环折环。另外一例患者表现为左右心房同时参与的双房大折返，进一步说明了心外科手术后大折返房速的复杂性。

在消融治疗时，由于心房基质的复杂改变，除了目前心律失常的折返环路外，可能还有其他潜在的折返环存在，因此在消融终止本次心动过速后，需反复诱发验证，甚至要对潜在折返环进行预防性干预，以减少术后其他房速的发生，如国内学者对右房游离壁切口使右房产生3个解剖峡部的病例(切口疤痕与三尖瓣之间、切口疤痕与下腔静脉之间、自身的三尖瓣峡部)，提出“三去二”原则[13]。本组中一例绕右房游离壁疤痕的“8”字双环返环的患者，首次仅消融了疤痕之间的共同峡部，并从疤痕向下腔消融阻断，术后复发为三尖瓣峡部依赖的房扑。因此在心外科术后房速的患者，在消融终止本次临床表现的房速外，还需对可能的折返环路进行预防处理。

心外科术后房速的形成机制多样，但绝大部分以大折返的机制存在，极少数为微折返或局灶起源。由于手术疤痕与基础心源性疾病的共同作用，

心房基质变化复杂,大折返的房性心动过速可表现为双环折返或双房大折返。消融时除终止本次临床表现的心动过速外,还需根据心房基质的情况做预防性消融。

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(编辑　孙慧兰)